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SPECIAL BIBLIOGRAPHY 64-15

**CREATIVITY, INNOVATION, AND INVENTION:
AN ANNOTATED BIBLIOGRAPHY**

Compiled by
**GEORGE R. EVANS
PETER R. STROMER**

Lockheed

MISSILES & SPACE COMPANY

A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

SUNNYVALE, CALIFORNIA

ABSTRACT

The recent business management literature has been surveyed to assess the current trends and developments in the field of creativity, innovation, and invention. The accelerating pace of technological change and its effect on aerospace research and development activities has prompted this survey. The literature reveals that some tentative yardsticks are now available to identify creative talent and the means for optimizing its usage in industry. The importance of innovation and its successful implementation by both the military and the aerospace industry is stressed as companies seek to adapt their work force and facilities to new markets.

Key Sources Consulted:

Business Periodicals Index Jan. 1963 - June 1964
Engineering Index Jan. 1963 - June 1964
Applied Science & Technology Index Jan. 1963 - July 1964
Rand Index Jan. 1963 - March 1964
IMSC card catalog

Current issues of Fortune, Harvard Business Review, and other management periodicals in IMSC collection.

Search completed August 12, 1964.

CREATIVITY, INNOVATION, AND INVENTION:
AN ANNOTATED BIBLIOGRAPHY

1. Alexander, T.

The wild birds find a corporate roost.

FORTUNE 70: 130-134 ff, August 1964

Portrait of the genus "blue-skyer" or "wild bird" who dreams out beyond the frontiers of conventional long-range planning. These individuals are being hired to work way out where foresight merges with fantasy. Companies like General Electric and American Tel. and Tel. value their role in keeping the inventive juices flowing.

Pure invention in this age of intensifying competition is more important than it ever was, for many technologically nimble and hungry companies are willing to encroach upon almost any field in their powerful urge to diversify.

2. Ashworth, F. L.

Environmental effects on creativity. In Proceedings,

16th Annual Conference on the Administration of

Research, French Lick, Indiana, 16-19 Sept. 1962.

Published by University of Denver, 1963, p. 72-76.

Admiral Ashworth is Assistant Chief for RDT&E, Bureau of Naval Weapons. He believes the present environment in the Navy Dept. is not conducive to the emergence of novel and radical ideas. The DOD program packaging and planning processes tend to force individuals into the trap of pre-selecting weapon systems. The levels of management review, justification, and approval tend to stifle imaginative forward thinking. Exploratory steps to improve the situation include the organizing of a group of key technical people in the Bureau of Naval Weapons who personally get down to the level of the people actually doing research and development. They by-pass formal presentations and negotiate directly with the men who have the most ideas, at any level.

3. Bellman, R. E.

Creativity and research in the university. Rand
Corporation report P-2860. Jan. 1964

An inquiry into factors that foster or hinder significant research in colleges or universities. Author maintains that (1) the way to train an individual to be creative in the theoretical domain is to keep the image of the real world constantly in front of him and simultaneously teach him how to abstract ideas and problems from observed phenomena; and (2) that new ideas and new results can be produced by directing graduate students of ordinary ability and intelligence into new areas containing sound problems.

4. Benton, M.

Creativity in research and invention in the physical
sciences; an annotated bibliography. Naval Research
Laboratory Bibliography no. 19. June 1961.

A bibliography of around 1500 entries recording information obtained from a review of biographical material of creative individuals, results of research on thinking, and problem solving, tests and measurements, proceedings of conferences seeking an insight into creativity, and articles and books. Entries were selected because of their application to the research environment.

5. Bergen, S. A.

Research, development and innovation. INSTITUTION
OF ELEC. ENGINEERS JOURNAL 9:468-70, Nov 1963.

Reasons for, and possible ways of eliminating time lag that exists between conception of original scientific or engineering idea, and its translation into commercially successful product; examples of zipper, fluorescent lamp, magnetic recording, selfwinding watch, gyro compass and microanalyzer are cited; importance of timing; communication problems.

6. Corson, J. J.

Innovation challenges conformity. HARVARD BUSINESS
REVIEW, 40: 67-74, May/Jun 1962.

Six conditions are offered to a manager for stimulating a continual flow of ideas for change: (1) Not only trained, but especially creative people must be recruited; (2) Those recruited must be stimulated to produce ideas; (3) The organization must be designed to utilize people well; (4) The manager must be capable of asking questions which elicit creative responses and ideas; (5) The good manager makes every effort to keep the ablest minds alive, stretching those minds by providing more and unexpected responsibilities; (6) The innovator must be taught to sell his ideas.

7. Creativity: circling the pyramid.

PRODUCT ENGINEERING 34: 52, Jul 22, 1963.

A report of the symposium at George Washington University's Patent, Trademark and Copyright Foundation. Which technique is more efficacious for innovation - the carrot or the stick? While the question remained unanswered, the main speaker thought that a management structure in the form of a sphere rather than a pyramid would be more conducive to creativity.

8. Goldner, B. B.

THE STRATEGY OF CREATIVE THINKING

Englewood Cliffs, New Jersey, Prentice-Hall, 1962.

Author discusses the methods and techniques of creative individuals. Chapter 7, "Scientific Creativity", discusses creative and comprehensive science, attitudes of the young thinking scientist, and techniques in scientific breakthroughs. Essence of the chapter: (1) A creative scientist must dream a dream and build it. (2) Scientists must be young thinking, schooled in fact, and urged to practice fancy. (3) The creative scientist is not bound by the known, but motivated by the unknown. (4) Scientific knowledge is limited. Scientific imagination is boundless. (5) The modern scientist must be creatively curious, constantly probing, ready for the happy accident, have indefatigable industry.

Management support for basic research is stressed, wherein management is urged to develop a climate of creativity and sponsor a continuing program for idea production.

9. Guzzardi, W., Jr.

Man and corporation. (The Young Executives, Part 2).

FORTUNE 70: 146-148 ff, July 1964.

As the business world becomes more fluid, more open to innovation, corporations demand executives who have a high degree of initiative and self-reliance. The presence of such men in management speeds up the changes that are occurring in the business organization itself.

10. Haefele, J. W.

CREATIVITY AND INNOVATION

N.Y., Reinhold, 1962

Author discusses the nature of creativity and the theories about it, with continuous emphasis on relating this knowledge to the importance of creativity in business, especially in the field of industrial research and development. The need for a good climate for creativity must be understood by the practical businessman, and he must appreciate the reasons why an organization must make certain concessions to the creative man.

11. Hemmingway, H. L.

Creativity and the physical environment.

RESEARCH/DEVELOPMENT 15: 49-52, March 1964.

In designing to maximize creativity, the research people should be queried for ideas of environment of creativity. In the past, the plush offices have gone to management types with the scientists and engineers relegated to their "bench" and crowded cubbyholes.

12. Herwald, S. W.

Appraising the effects of the technological state-of-the-art on corporate future. In TECHNOLOGICAL PLANNING AT THE CORPORATE

LEVEL, Bright, J. R., ed., Boston Harvard Business School

1962, p. 52-69.

Author's guidelines: (1) Choose those areas of technology that bear on a particular functional performance, (2) Be aware of proper timing for profitability considerations, and (perhaps most important in the aerospace industry) (3) Pay particular attention to those technologies that are likely to change the mode of the business we're in.

13. How to spot creative employees.

IRON AGE 193:73. April 23, 1964

Creative individuals are more able to generate a large number of ideas rapidly, shift mental gears quickly, change approaches spontaneously, and discard one frame of reference for another. Highly creative thinkers are more apt to stick to their guns when they get into disagreements. They view authority as conventional, arbitrary or expedient, rather than with feelings of personal allegiance or moral obligation.

14. Inventions profit in byproducts.

PRODUCT ENGINEERING 35:35. March 2, 1964

While working on an assignment, a scientist or engineer may have an idea for a design, which, while not applicable to his present work, may prove to be marketable. The idea should be developed either by the scientist's company or licensed to an outside organization for development.

15. Jones, S. L. and J. E. Arnold

Creative individual in industrial research.

IRE - TRANSACTIONS ON ENGINEERING MANAGEMENT

EM-9(2): 51-55, June 2, 1962.

Project was undertaken to analyze processes associated with individual creativity in industrial research organizations and effects of company environment and management policies on results of research and development (R and D) activities; one aspect of study concerned dichotomy of research specialist vs generalist; data on wide range of characteristics and attitudes of research people are presented.

16. King, B.

Object: creativity

MECHANICAL ENGINEERING 85: 38-41, Nov 1963.

Six maxims are offered to assist in developing engineering creativity. Essentials: Dig deep. Define problems in strictly functional terms. Bring the resources of modern technology to bear and think up new solutions to the problem. Choose the best one and carry it out. Recognize that every work of man represents an imperfect solution to a problem.

17. Land, E. H.

Role of invention in organized society.

PRODUCT ENGINEERING 35: 60-62. March 2, 1964

An inventive process is a difficult thing to push across because of the barriers it encounters: The inventor must perceive an error or an inert region of science required for the execution of his concept. He must alter engineering habits existing in his field. He must persuade merchandising people that there is a latent public need for his product. He must show that the defects in his proposed undertaking are not fundamental, but merely an aspect of the early stage of his development. Fixed attitudes prevail in science, as well as in politics and religion. The inventor has to prove these attitudes wrong.

18. Levitt, T.

Creativity is not enough (need for implementation of ideas in business). HARVARD BUSINESS REVIEW 41: 72-83. May 1963.

Not only idea men are needed, but also the man to implement these ideas. Author believes the creative individual should be called upon to take added responsibility for the implementation and development of his ideas. Author also points out that the large organization has same important attributes that actually facilitate innovation. Its capacity to distribute risk over its broad economic base and among the many individuals involved in implementing newness is significant.

19. Little, Arthur D., Inc.

How sick is the defence industry?

Arthur D. Little Report no. C-57904-51. 10 May 1963.

The United States Department of Defense is the biggest customer for goods and services in the free world. A vast industry has sprung up in the past 25 years to satisfy the demands of this monolithic consumer. Because of the very size of DOD, its unique requirements, and the necessity that it be primarily concerned with the quality of an intangible product--defense--rather than normal commercial goals, the defense industry has, in turn, developed some curious attributes.

This report consists of eight sections devoted to: an introduction, a description of the defense market as it currently exists, a survey of the legal framework that surrounds defense contracting, a discussion of industry profitability, a suggested approach to realistic financial analysis of the industry, an evaluation of the risks involved in serving the market, a brief look at what the future will hold for contractors, and, finally, some thoughts relevant to planning for profitable participation in tomorrow's market. An extensive bibliography is provided for those who wish to pursue the subject further.

20. Little, Arthur D., Inc.
Patterns and problems of technical innovation in
American industry. Report to the National Science
Foundation. Sept. 1963. Arthur D. Little Report
No. C-65344. Available from Office of Technical
Services, Commerce Dept. as PB 181573.

Background information, technical innovations, patterns, and problems of innovation are given for the textile, semiconductor, machine tool, and building industries. (Not reviewed.)

21. Little, Arthur D., Inc.
Problems of innovation in American industry.
Report to U.S. Dept. of Commerce, May 1963,
Arthur D. Little Report no. C-65275. Available
from Office of Technical Services, Commerce Dept.
as PB 181 572.

Independent inventors and new small firms suffer from lack of financial, technical, marketing, and informational resources. Large firms suffer from the need for new skills and new organizational models in order to use more effectively the very considerable resources they possess. A summary is given of a conference on problems and patterns of the technical innovation. (not reviewed).

22. McCune, F. K.
Creative designer needs three information inputs.
SAE JOURNAL 71: 36-37, May 1963.

Engineers are responsible for design; for the expression of creative, inventive ideas. Raw material for ideas is information. What information does an engineer need to be able to design? Two information inputs are pretty well known and recognized: "scientific knowledge of nature" and "engineering technology". The third need is a cross-correlation of these two with other relevant information: public needs, marketing, psychology, etc.

23. Military seeks designs.

PRODUCT ENGINEERING 35: 41, March 2, 1964

To prove that the market for new and advanced military products is still active, the National Inventors Council periodically publishes a list of inventions that the military services are seeking. This latest list contains 400 problems.

24. Mullins, C. J.

Prediction of creativity in sample of research

scientists. TRANSACTIONS ON ENGINEERING MANAGEMENT

EM-10(2): 52-57, June 2, 1963.

To identify test predictors of scientific creativity, 2 criteria were used, supervisors' ratings and number of publications; interest questionnaire, vocabulary test and 9 tests of Guilford Creativity Battery were administered to 131 research physical scientists; of 42 test scores, 4 were significantly related to rating criterion and 7 to publications criterion; criteria were not significantly related to each other and none of predictor scores correlated significantly with both criteria; composite predictor gave promise of increasing effective prediction of ratings criterion only.

25. Mruphy, C. J. V.

The defense industry is facing trouble.

FORTUNE 70: 140-142 ff, August 1964.

The slowdown the Pentagon has ordered in weapon procurement and development may force shakeouts and mergers, will displace many workers, and is already jeopardizing a great research apparatus. There is apprehension, because no new massive programs looking to further experiment, invention, and production are taking tangible shape beyond the contracts being disposed of at present. Concern is evidenced by the fact that the onrush of invention in the field of strategic weapon systems has provided the leading edge for the technological buoyancy that lifted the entire aerospace industry to affluence.

26. National Bureau of Economic Research

The rate and direction of inventive activity:

economic and social factors.

Princeton, New Jersey, Princeton U. Press, 1962.

Papers presented at a conference held at the University of Minnesota in the Spring of 1960. Almost all of the papers were written by economists. Case studies, non-market factors, efficiency in research and development are considered. Modern circumstances require that increasing attention be given to the roles of discovery and invention in economic and other cultural change. Among the relevant circumstances are: the multiplication and enlargement of corporate research programs; the annual outlay of billions of public dollars for private contract research; the clarification of the Internal Revenue Code accounting rules regarding the treatment of private research costs; the increasing importance of the scientific and technical dimensions of national defense; and the relation of these factors to new and impressive advances in information-handling technology.

27. Parnes, S. J., and H. F. Harding, Eds.

A SOURCE BOOK FOR CREATIVE THINKING.

N.Y., Charles Scribner's Sons, 1962.

The editors have selected what they believe to be the most significant articles published on the subject of creative problem-solving covering the period 1950-1960. An excellent annotated bibliography of 59 references is included in an appendix entitled a "Compendium of Research on Creative Imagination".

28. Paulson, R.

We have others, so why not a creative specialist?

PRODUCT ENGINEERING 34: 80-81, Nov 25, 1963.

Author offers a new job category to be titled "Creative Specialist", with only one major responsibility - to invent. Normal qualifications would be to require only that the individual show proof of having inventive talents and ability; i.e., the individual must have been granted a patent or patents at his/her own expense.

29. Raudsepp, E.

MANAGING CREATIVE SCIENTISTS AND ENGINEERS

N.Y. Macmillan, 1963.

Book is divided into three parts: Part 1 - Creativity, the process and the individual; Part 2 - Creativity in culture and industry; Part 3 - Managing creative research. Author believes the most pivotal factor in the entire research and development effort is not so much capital accumulation and natural resources as it is the effective utilization of scientists and engineers. It may well be that the question of our very survival now depends on the creativity of our scientists and engineers and the rate of our technological and scientific advance and growth.

30. Raudsepp, E.

Removing barriers to creativity.

MACHINE DESIGN 34(12): 138-143, May 24, 1962.

Discussion of methods for removing blocks and barriers to creativity as first step in improving problem-solving ability; how more common blocks and barriers can be recognized and overcome.

31. Raymond, R. C.

Betting on new technologies. In TECHNOLOGICAL

PLANNING AT THE CORPORATE LEVEL, Bright, J. R., ed.,

Boston, Harvard Business School, 1962, p. 12-39.

Author is Manager, Technical Military Planning Operation (TEMPO), General Electric Co., Santa Barbara, Calif. He describes two research tools used by TEMPO, the broad-scale environmental study and the comparison of customer choices, in such areas, for example, as predicting future USAF requirements.

32. Rewards for invention.

PRODUCT ENGINEERING 34: 60-63, April 29, 1963.

Discusses the pros and cons of rewarding engineers for their ideas. Compares Lockheed's generous patent policy (with an example) to Ling-Temco-Vought, who, in contrast, has abandoned its participating policy.

This article includes:

A view from the outside.

Holliday, T. B.

What Royalties Should An Outside Inventor Get From a Company?

Because of the environment of a large company, many creative men prefer to free-lance and take the risk of being able to sell their ideas for commercial exploitation.

33. Safford, D. E.

Proper word isn't creativity; it's innovation

we want. PRODUCT ENGINEERING 34: 112-13, Dec 9, 1963.

Largely a matter of semantics, the author believes that no human being is capable of creativity. The word alone gives the implication of the supernatural. Hence, the preference for "innovation" is stated. Article is a rebuttal to the earlier article "Today's creativity" by Tangerman. (Q.V.)

34. Schaffranke, R.

Hic deficit orbis; established authority resents

and resists changes. PRODUCT ENGINEERING 34: 99,

March 18, 1963.

Late in the sixteenth century, Sir William Gilbert said, "Science has done its utmost to prevent whatever science has done". Established authority resists and resents changes. It always has - but new ideas get hearings anyway.

35. Schon, D. A.

Champions for radical new inventions(problems

of significant technological innovation in

business and the military). HARVARD BUSINESS

REVIEW 41: 77-86, March 1963.

Most large industrial organizations share the military's ambivalence toward startling innovations. Needed are product champions willing to fight for the success of new concepts. The product-champion approach grows out of the sharp division between those in top management who dispose and those, lower in the organization, who propose. Product champions would be needed less if the risks of product change were more evenly distributed. A willingness to pay the price of innovation, with top management giving up some of its prerogatives to dispose of what others propose, is needed to achieve technological progress.

36. Schon, D. A.

How companies strangle innovation.

MANAGEMENT REVIEW 52: 44-47, Sept 1963

Resistance to change is a primary reason for the lack of innovation; this is understandable because of the risks involved in new-product development. Demands for innovation put new stresses on the workings of a company. The vulnerability of the firm's management structure may be exposed, showing that the present organization is incapable of meeting new demands.

37. Schon, D. A.

Innovation by invasion.

INTERNATIONAL SCIENCE AND TECHNOLOGY, 52-60, March 1964.

If we are to deal with automation in ways that will not hurt millions of people, we must learn how to deal with the problems of technical change, how to encourage the development of new ideas, and how to help people whose skills belong to old technologies to learn new work in new technologies. Author calls for (1) the adoption of government policies which facilitate technical innovation, (2) promotion of worker retraining and movement to new jobs, (3) helping distressed regions build new industries based on new technologies, (4) encouraging threatened industry to find its way to new, growing businesses, and (5) using techniques which will help to predict the social consequences of technical change.

38. Schriever Disputes "Plateau" Theory

AVIATION WEEK AND SPACE TECHNOLOGY, p. 31,

Nov 11, 1963.

In a speech to a Vehicle Design and Propulsion meeting sponsored by the AIAA and AFSC ASD, General Schriever disagreed with those who claim there is nothing left to invent and said there is still a potentially rich field of development for military aircraft and in other areas. He went on to say that the Long Range Forecast Panel of the AIAA had listed as many as 40 different types of advanced military aircraft that looks theoretically feasible.

39. Sparks, W. J.

Invention: vital third dimension of science;

editorial. INDUSTRIAL & ENGINEERING CHEMISTRY

PRODUCT RESEARCH & DEVELOPMENT 3: 1-2, March 1964.

Author calls for strengthening the U.S. Patent System to encourage inventors. With a patent system that is strong, companies can maintain an energetic program of industrial innovation with suitable rewards for individual inventors. Few inventors today can afford to invent without financial backing. And few companies can afford to invest millions in a man's ability to invent without the promised security of a strong patent.

40. Tangerman, E. J.

Creativity - what is it.

PRODUCT ENGINEERING 33(43): 63-65, Dec 11, 1961.

Preliminary findings of research studies supported by Carnegie Foundation and conducted at University of California, University of Michigan, New York University, and other institutions; characteristics of creative individuals; personality types; creative man and his environment. Note on Intuitive Engineering by H. J. Jackson on same pages parallels with research results in preceding article.

41. Tangerman, E. J.

How much return? (Editorial)

PRODUCT ENGINEERING, p. 11, May 11, 1964.

Creativity has developed into an omnibus term meaning everything. In the ultimate, it (creativity) is the rewriting of a natural "law" - a proof that what has been accepted is wrong. Is the assembly of familiar components in a different manner creative? What order of magnitude constitutes a change worthy of the name? It is important, if we are to retain a sense of perspective and maintain a budget that we recognize degrees of difference between problem solving, innovation, invention, and discovery.

42. Tangerman, E. J.

How valuable are ideas? (Editorial)

PRODUCT ENGINEERING 34(15): 11, July 22, 1963

As important as an innovation is, it is equally important to determine whether that innovation will justify its development cost in terms of sales and profits.

43. Tangerman, E. J.

Some thoughts about today's creativity.

PRODUCT ENGINEERING 34: 105-107, Sept 16, 1963.

There is a very real conflict between the concepts of creativity and sound management. Creativity demands the sacrifice of everything else to ideas; management demands a devotion to conformity, to solidarity as a way of generating and enhancing profit. Better understanding is offered as a solution. Six factors that discourage creativity are (1) unawareness of problem opportunities, (2) lack of incentive, (3) lack of knowledge, (4) unfortunate habits, (5) emotional hazards, (6) cultural pressures.

44. Tangerman, E. J.

Where do ideas come from?

PRODUCT ENGINEERING 34: 94-98, March 18, 1963.

In the government contractor, Research has "way-out dreams" to meet a need. Usually, the order of advance over earlier designs (if there are any) is 75 to 100%, so a new solution is called for. If the idea has the remotest chance, the company will seek a contract-exploratory, then R&D, in each case selling a promise and some blue sky. Most break-throughs are here. One weakness here is that the company cannot fund the project therefore dependent on the government. This dependency increases government participation and leads to wrangling over rights of ownership. To continue this line of thought, if the idea has no immediate military or space application and cannot be sold at once, it's dropped.

45. Taylor, C. W.
A search for a creative climate. In PROCEEDINGS
17th National Conference on the Administration
of Research, Estes Park, Colorado, University of
Denver, Sept. 11-13, 1963, p. 106-114.

Author is a psychologist who has done studies on communication abilities and creative abilities of Air Force and NASA scientists. He offers the following advice to managers of research: "If you do want creative talent, you must pay the price of being willing to take our scientific findings at this stage and use a fairly long battery of tests that measures creative characteristics."

46. Taylor, C. W. and F. Barron, eds.
SCIENTIFIC CREATIVITY: ITS RECOGNITION AND
DEVELOPMENT. N. Y., Wiley, 1963.

Selected papers from the Proceedings of the first three University of Utah conferences on the Identification of Creative Scientific Talent. The collection of papers indicate that it can no longer be said that fruitful research cannot be done on creativity. Instead, there are now many leads to pursue at this relatively early period of serious scientific research on creativity.

47. Taylor, C. W., ed.
CREATIVITY: PROGRESS AND POTENTIAL
N.Y., McGraw-Hill, 1964.

A report of six highly selected participants on the status of research knowledge in creativity, plus the promising leads and urgent needs for further research. (Not reviewed)

48. Taylor, J. W.
HOW TO CREATE NEW IDEAS
Englewood Cliffs, New Jersey,
Prentice-Hall, 1961.

Book is alleged to be a comprehensive course in the art and science of creative thinking. Author refutes the notion that creative ability is some strange, mysterious, esoteric, faculty. He believes that every human being has some creative ability - most of it latent. Eleven creative thinking techniques, such as brainstorming, attribute listing, free association, forced relationships, etc. are explained

49. Williams, F. C.

How to invent.

INTERNATIONAL SCIENCE AND TECHNOLOGY, pp 49-53,

Feb. 1964.

Transcript of an interview with the inventor of the Nipkow Disk system for mechanical scanning of television pictures and the Williams Storage Tube used in computers. Some of Prof. Williams provocative comments include: "No one can teach you how to invent. The best you can do, if you were born with the talent and the naysayers haven't killed it, is to apprentice yourself to an inventor" ... "I think it's a great mistake to learn too much, to be too good at any one thing, because this tends to become important in itself." ... "There's only one easy place to be in science and in engineering and that's in the front. If you're there first, you have nothing to read. You've got all your time to think."